The Victorian Naturalist

Volume 134 (1) February 2017

Published by The Field Naturalists Club of Victoria *since 1884*

From the Editors

We begin this year of publication with Research Reports on three different aspects of the natural history of Victoria. The field work upon which these papers is based was carried out in dissimilar environments within the western half of the state, taking in basalt plains grasslands, heathy woodlands in the Otway Ranges, and lake bed herblands in the Murray River floodplain. This diversity of ecological settings is mirrored by the variety of subjects upon which the research focused.

In today's world, no individual can hope to study all of nature satisfactorily; various degrees of specialisation have long been required. It is one of the roles of journals such as this to present the results of contemporary work on the widest range of natural history subjects. This issue of *The Victorian Naturalist* is offered with this in mind. Ultimately, we are limited by available resources and the ebb and flow of submissions but we endeavour to address the widest possible audience. We trust readers will find something of interest in this first issue for 2017.

The Victorian Naturalist
is published six times per year by the

Field Naturalists Club of Victoria Inc

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.
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Single	$ 82	Institutional	
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The

Victorian Naturalist

Volume 134 (1) 2017 February

Editors: Gary Presland, Maria Gibson, Sue Forster

Editorial Assistant: Virgil Hubregtse

ISSN 0042-5184

Front cover: Swamp Antechinus *Antechinus minimus maritimus*. Photo Ash Renaut.

Some observations and a review of the variation in banding patterns of juvenile Eastern Brown Snakes *Pseudonaja textilis textilis* (Elapidae)

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Abstract

The occurrence of juvenile Eastern Brown Snakes *Pseudonaja textilis textilis* with body bands from Werribee–Keilor plains grasslands near Melbourne is documented and a literature review of the variation in banding patterns across the species' geographic range is examined through published descriptions and photographs. The frequency of banded juveniles from Werribee–Keilor plains was 18% (n = 7) and the number of body bands ranged from 10 to 60. The number of body bands on Victorian juveniles was generally smaller (≤ 55) than the number of bands on juveniles from NSW (55+) (n = 38). Overall, the number of body bands ranged from 2 to approximately 90, they were typically 1 to 2 dorsal scale lengths in width, and the occurrence of incomplete bands was widespread and reasonably common (43%; n = 16). (*The Victorian Naturalist*, 134 (1), 2017, 4–11)

Keywords: Eastern Brown Snake, *Pseudonaja textilis textilis*, juveniles, body bands, Werribee–Keilor plains

Introduction

The distinctive and variable markings of juvenile Eastern Brown Snakes *Pseudonaja textilis textilis* have long been known (Krefft 1869; Waite 1929) and are such a contrast to the unpatterned adults that the juveniles were more than once described as separate species (e.g. McCoy 1879). All juvenile *P. t. textilis* have black pigment on the top of the head and a broad black band around the neck (the nape or nuchal band) but are polymorphic with respect to occurrence of regularly spaced, black cross-bands along the length of their body and tail (hereafter referred to as 'body bands'). Some juveniles possess body bands to varying degrees while others lack them entirely. Those that possess them, show considerable variability in banding pattern (i.e. in the distribution, number, thickness and completeness of bands) and also in dorsal ground colour, even within clutches (Krefft 1869; Waite 1929; Cogger 1992; Greer 2000), but the extent of it has not been adequately described. Juvenile markings gradually disappear with age although there are few definite statements about the age or size at which this occurs (Krefft 1869; Jenkins and Bartell 1980; Griffiths 2006). The presence or absence of banding was found to be unrelated to the sex of the juvenile and the incubation temperature of the eggs; however, this was determined for just a single clutch (Shine 1989). The evolutionary significance of juvenile polymorphism is not known (Shine 1991). Neither the black head markings or body bands are seen in adult *P. t. textilis* (Krefft 1869; Cogger 2014).

The aim of this work is threefold: (i) describe examples and determine the frequency of banded juvenile *P. t. textilis* from the Werribee–Keilor plains to the north and west of Melbourne, (ii) establish the extent of the observed variation in banding patterns across the species' geographic range by reviewing the literature on the subject and by conducting online searches for images with locality data, and (iii) determine any geographical trends in banding patterns.

Observations

Field observations took place between 1983 and 1993 during general searches for reptiles in remnant grasslands on the Werribee–Keilor plains to the north and west of Melbourne. All snakes were located beneath surface (basalt) stones, mostly during winter months when the species was inactive. The two localities (see below) where banded juveniles were found were approximately 9 km apart. All juvenile *P. t. textilis* described below were 22 to 30 cm in total length, indicating there had been minimal growth post-hatching, based on hatchling sizes in Shine (1989) and Greer (2000), and that snakes were <12 months old. In each snake the following characteristics were noted: (i) the number of body bands (including those on the tail); incomplete and bifurcated bands were

included in counts, (ii) the width of the body bands (expressed in terms of the number of dorsal scale lengths) in the mid-body region, (iii) whether body bands faded posteriorly along the body/tail, and (iv) whether or not the head patch and nape band were in contact. The dorsal ground colour was also noted.

A total of 38 juvenile *P. t. textilis* were located and of these seven (18%) possessed body bands and are described below. Of 14 additional larger juveniles/sub-adults with total lengths in the range 0.4 to 0.7 m (presumed one- to two-year-olds), only two (14%) possessed faint body bands; all possessed faint bands on the head and neck.

1. June 1983, Thomastown (34°41′ S, 145°03′ E, 109 m ASL). Beneath the same stone were two adult Little Whip Snakes *Parasuta flagellum* and two juvenile *P. t. textilis*, the latter in direct body contact. The two *P. t. textilis* were very different in appearance: one was reddish-brown dorsally with 30 to 35 black body bands that were 1–2 scales wide; at least eight bands were incomplete being confined to either the left or the right side of the body, terminating near the vertebrae/midline (hereafter referred to as 'half-bands' (Fig. 1A); the other juvenile was fawn brown dorsally with no body bands. The head patch and nape band were solid black for both and were not in contact.
2. September 1983, Thomastown. Beneath the same stone were two juvenile *P. t. textilis*. One had 15 body bands, the other had 20 body bands, six of which were half-bands. Bands were 1–2 scales wide in both juveniles. The head patch and nape band were solid black in both snakes and narrowly fused along the midline.
3. July 1988, Somerton (37°38′ S, 144°58′ E, 155 m ASL). A juvenile *P. t. textilis* with approximately 30 bands was located. While most of the body bands were entire, about one-third of them were half-bands and were 2 scales wide. The head patch and nape band were solid black and narrowly fused along the midline.
4. July 1989, Thomastown. A juvenile *P. t. textilis* with 55–60 bands was located. Three bands were incomplete and another two were bifurcated. Body bands were 1.5–2 scales wide. The head patch and nape band were solid and broadly in contact.

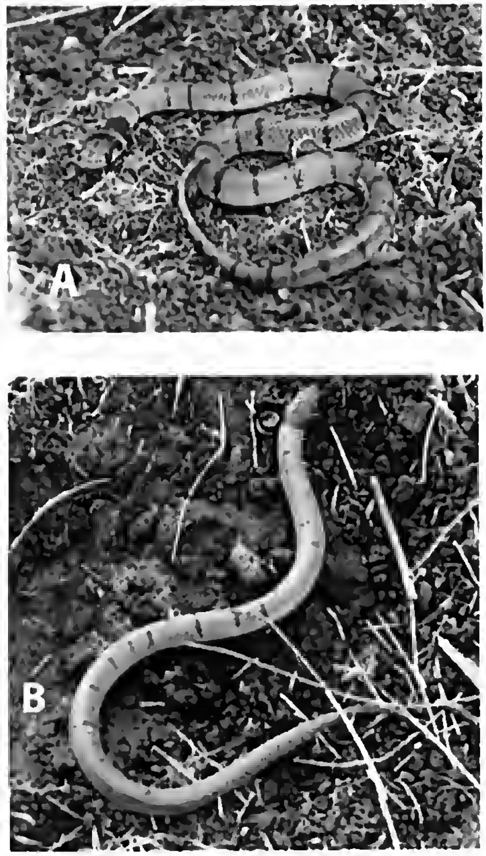

Fig. 1. Two juvenile Eastern Brown Snakes *Pseudonaja textilis textilis* from the Werribee–Keilor plains: **A.** Juvenile with a mixture of complete and incomplete bands; **B.** Juvenile with few, irregularly spaced, and mostly incomplete bands.

5. August 1991, Somerton. A juvenile *P. t. textilis* was found with 15 bands, only three of which were complete; the remainder were incomplete (to varying degrees) and irregularly spaced (Fig. 1B). Body bands were 1–1.5 scales wide. The head patch and nape band were solid black and broadly in contact.
6. July 1992, Somerton. Three juvenile *P. t. textilis* were lying within 80 mm of each other beneath the same stone. Two lacked body bands while one had 15 body bands, four of which were half-bands. Body bands were 1–2 scales wide. One unbanded juvenile was orange-brown dorsally with a faint head patch and nape band; the other two juveniles were

intermediate and fawn brown with solid black head patches and nape bands; in the banded juvenile these were narrowly fused along the midline.

The occurrence of small numbers of juvenile *P. t. textilis* together beneath the same surface stone (observations 1, 2 and 6 above) may indicate that they are siblings; however, adult *P. t. textilis* have been known to form aggregations during the cooler months when inactive (Hoser 1980, 1991). Furthermore, small aggregations are also seen in juvenile and in adult *P. flagellum* in the same habitat, sometimes together with *P. t. textilis* during the cooler months (Fyfe and Booth 1984; Turner 1989). Hence the co-occurrence of juvenile *P. t. textilis* may result from factors other than limited dispersal from the oviposition site and I treat each individual as an independent observation.

Review of literature records and published photographs of banded juveniles

Data on the banding patterns of juvenile *P. t. textilis* were gathered from published descriptions and photographs. Almost all reference books and field guides on Australian reptiles were consulted and attempts were made to consult all journal articles that pertained to the taxonomy, biology and ecology of *Pseudonaja* spp. Furthermore, multiple search engines, popular photo-sharing sites and online naturalist databases (Bowerbird, NatureShare, iNaturalist and also the Atlas of Living Australia) were used to locate digital photographs of juvenile *P. t. textilis* with provenance specified. Sites were last visited on 18 July 2016.

A summary of the results is given in Table 1. There is surprisingly little detailed information available on banding patterns in juvenile *P. t. textilis* in the herpetological literature. Locality data was lacking for some juveniles in print publications (e.g. Worrell 1963; Kinghorn 1956; Gow 1976, 1989; Weigel 1990; Shine 1991) and for many more whose images are available online. These were not included in the table.

A comparison of the number of body bands possessed by Victorian juveniles (nos. 23–36, Table 1) and NSW juveniles (nos. 3–8, 10–18, Table 1) indicates that those from Victoria generally possessed fewer body bands. Banded juveniles from Victoria typically had 55 or fewer body bands (median 30) whereas NSW juveniles typically had more than 55 bands (median 60). There is, however, some overlap in the number of bands possessed by Victorian and NSW juveniles (e.g. nos. 5, 36, Table 1). Two notable exceptions to this trend were specimens from the ACT (nos. 21 and 22, Table 1) with low body band counts; however, in both snakes the bands faded posteriorly (and were entirely absent from the tail) resulting in the lower counts. Some reference/identification guides omit to mention the number of body bands possessed by juveniles, but several authors do and these are consistent with the NSW samples in Table 1 (70–80 Krefft 1869; 50+ Cogger 1992). Commenting on Victorian juveniles, Kershaw (1927: 336) stated 'Many examples have only two or three rings', consistent with the generally lower band counts evident in Table 1. Sample sizes for both Queensland and SA specimens were too small for any valid comparisons to be made. The largest number of bands recorded on a juvenile (of unknown provenance) was approximately 90.

No differences were apparent in band spacing and band width between Victorian and NSW samples (Table 1). There was considerable variability in band spacing (e.g. Homan 2008, 5–9 scale lengths versus Swan and Wilson 2008, p. 79, 2–3 scale lengths) but there was no obvious geographic trend. Body band width ranged from 1 to 2.5 dorsal scale lengths (band widths of 3 scale lengths were seen in some published photographs) but nearly all were 1–2 dorsal scale lengths wide (97%; 37 of 38). The nape band was typically a maximum of 4–5 scale lengths wide and tapered as it approached the ventral surface; the band immediately following it (i.e. the first body band) was often slightly thicker than all other bands. In some juveniles there was variability in band thickness along the length of body but this was usually less than one scale length. Most banded juveniles did not exhibit posterior fading of the bands (72%; 23 of 32). The head patch and neck bands were often separated (62%; 21 of 34) or else narrowly in contact along the midline. Dorsal ground colour varied considerably, being many shades of either grey or brown, and variation was evident in juveniles even from the same clutch, with no geographic trends apparent. Annable (1985)

also noted variation in the width, number and arrangement of body bands in six juvenile *P. t. textilis* from the eastern Riverina region.

The occurrence of juvenile *P. t. textilis* with one or more incomplete bands or half-bands on the body appears to be widespread and reasonably common (43%; 16 of 37). Kinghorn (1956) illustrated a specimen with bands 'broken' along the midline (i.e. half-bands as in observations 2, 3 and 5 above; also Krefft (1869) and Waite (1929) both describe this variation). The specimen figured in McCoy (1879) (and referred to above; no. 23, Table 1) is described as 'semi-banded' and with 'narrow distinct black bands often imperfect, on alternate sides'. Watharow (2000) recorded a (Werribee–Keilor plains) juvenile with 'faint half band rings'. These authors appear to describe individuals with incomplete bands that occurred consecutively and on alternate sides of the body. A similar pattern was seen in two Werribee–Keilor plains juveniles (above) and also in photographs of juveniles published online (n = 5). Specimens nos. 5, 6 and 27 (Table 1) all exhibited one or two half-bands. Some published photographs show (single) bifurcated body bands (n = 8; Swan *et al.* 2004, Griffiths 2006; Swanson 2007; also nos. 25 and 36 Table 1, plus three online photographs lacking locality data). Some juveniles exhibited faint bands in between the black bands (e.g. Gow 1976, plate 31).

The black juvenile markings of *P. t. textilis* disappear well before maturity is attained. Remnant bands have been commonly reported in immature snakes (e.g. Krefft 1866; Jenkins and Bartell 1980; Swan and Watharow 2005; Griffiths 2006) and in some instances are also seen in adult *P. t. textilis* (Krefft 1869; Waite 1929; McPhee 1959; Couper and Amey 2007, p. 47, bottom left; Swan and Wilson 2008, p. 79; pers. obs.). Jenkins and Bartell (1980) stated that the body bands persist for the first year while Fleay (1943) stated that juvenile markings occur in specimens up to 2 ft in length (0.61 m); similarly, Swan and Watharow (2005) stated that these markings usually disappear after two years at lengths 'around 600–800 mm'. These observations, along with those of juvenile *P. t. textilis* from the Werribee-Keilor plains (above), indicate the loss of black juvenile markings occurs between one and two years of age, though remnants of these markings may be permanent or else persist for much longer periods in some individuals. The occurrence of remnant bands in some adults indicates that there is variation in the persistence of bands. It was obvious from photographs of juveniles from various localities that considerable variation exists in the density of the black pigment on the head patch and nape band, and this may account for the variation in their persistence over time.

Discussion

In many reference sources and field guides it is implied (and sometimes stated) that unbanded juveniles are the typical or more common form (e.g. Swanson 2007) and that 'occasionally' banded juveniles occur or that they occur at some localities (e.g. Wilson and Knowles 1988). The proportion of banded juveniles determined in this work (18%) compares with 11% (or 18% if an additional four with 'faint' banding are included out of a total of 55) in juvenile *P. t. textilis* from Riverina region of NSW (Annable 1985), 11% (3 of 27) from a presumed single clutch from Campbellfield near Melbourne (Watharow 2000), 24% (4 of 17) from a partial clutch from Oakey, Qld and 100% (8 of 8; from a partial clutch from Windsor, NSW; Shine 1989). A number of authors have stated that juveniles are more strongly banded, or that there is a greater proportion of banded juveniles, in populations on the (wetter) NSW coast (east of the Dividing Range) compared to inland populations (Krefft 1869; Wells 1980; Hoser 1989; Shine 1991; Swan *et al.* 2004; Griffiths 2006). Swanson (2007) stated that around Sydney all juvenile *P. t. textilis* are banded. While there is no doubt some truth to these statements, the complete lack of data on the frequencies of banded versus unbanded juveniles from particular localities within these regions means that they remain unsubstantiated. Juveniles with relatively high band counts (55+) were recorded from both coastal and inland locations (see Table 1).

In examining banding patterns in juvenile *P. t. textilis* it is evident that the potential of photo-sharing sites and naturalist databases is not yet fully realised. Photo-sharing sites allow images of all kinds to be uploaded with minimal accompanying data. While naturalist data-

Table 1. Details of published photographs/illustrations/descriptions of banded juvenile Eastern Brown snakes *Pseudonaja textilis textilis* ordered according to locality latitude. Body band counts include incomplete and bifurcated bands.

No.	Locality	Head and nape bands separated?	Approx. number of body bands	Band width (in dorsal scale lengths)	Posterior fading?	Source
1	Sunshine Coast, Qld	Y	54	2 – 2.5	N	Jo Deverill[1]
2	Brisbane, Qld	Y	50	1	N	Wilson and Swan 2003[2]
3	North Coast/ Tablelands, NSW	Y	55+	1 – 1.5	N	McEwan 2005
4	Bendemeer, NSW	N	55+	1 – 1.5	?	Gary Stephenson[3]
5	Bendemeer, NSW	N	50	1	Y	Gary Stephenson[4]
6	Seaham, NSW	Y	55+	1	N	Scott Papworth[5]
7	Nelson's Bay, NSW	Y	60+	1.5 – 2	N	Cogger 1992
8	Pittwater NSW	Y	80	2	N	Peter Woodard[6]
9	Mid-north, SA	Y	2	1 – 2	N	John Fowler[7]
10	Blacktown, NSW	Y	60	1 – 1.5	N	Cogger 1992
11	St Clair, NSW	Y/Y	60+/60	1/1.5 – 2	Y/?	Hoser 1989
12	Sydney region, NSW	Y	70-80	1.5 – 2	?	Krefft 1866, 1869
13	Sydney region, NSW	N	60	1	N	Griffiths 1987
14	Sydney, NSW	N	80+	2	N	Swanson 2007
15	Sydney, NSW	?	60 – 70	1 – 1.5	N	Swan *et al.* 2004
16	Campbelltown, NSW	Y	65	1.5 – 2	N	Robert Gleeson 2013[8]
17	Goulburn, NSW	Y	70+	1.5	N	Swan and Wilson 2008
18	Beecroft Pen., NSW	N	60 – 70	1	Y	Jenkins and Bartell 1980
19	Canberra, ACT	Y	55 – 60	1	N	'Wombey' 1976[9]
20	Sutton, ACT	Y	55+	1	?	'Wombey' 1987[10]
21	ACT	Y	50	1.5	Y	Bennett 1997
22	ACT	Y	30	1	Y	Bennett 1997
23	Longwood, Vic	Y	20	1	Y	McCoy 1879
24	Lima East, Vic	N	48+	1	Y	Peter Robertson[11]
25	Strathbogie Ranges, Vic	?	50+	1 – 1.5	Y	Bertram Lobert[12]
26	Maindample, Vic	Y	30	1	?	Bertram Lobert[13]
27	Donnybrook, Vic	?	50	1 – 1.5	N	Rob Valentic[14]
28	South Morang, Vic	?	55	1 – 1.5	?	James Booth[15]
29	Somerton, Vic	N	30	2	N	This work
30	Somerton, Vic	N	15	1.5 – 2	N	This work
31	Somerton, Vic	N	15	1 – 2	Y	This work
32	Epping, Vic	Y	24	1	N	Homan 2008
33	Epping, Vic	N	10	1	N	Nicholas Gale[16]
34	Thomastown, Vic	Y	30 – 35	1 – 2	N	This work
35	Thomastown, Vic	N/N	15/20	1 – 2/1 – 2	N/N	This work
36	Thomastown, Vic	N	55 – 60	1.5 – 2	N	This work

Table 1 cont.

Notes to sources

1. http://stem.org.au/wp-content/mediauploads/Eastern-Brown-snake-var1.jpg

2. The same individual also appears in Swan & Wilson (2008) in a different photograph.

3. https://www.flickr.com/photos/gazs_pics/11473686013/in/photostream/

4. https://www.flickr.com/photos/gazs_pics/11473572684/in/photostream/

5. http://reptilesofaustralia.com/snakes/elapids/bandedbrownsnake.jpg

6. https://upload.wikimedia.org/wikipedia/commons/2/2c/Eastern_Brown_Snake_-_Resolute_Beach_Pittwater_NSW.jpg

7. http://reptilesofaustralia.com/snakes/elapids/ptextilis2.jpg

8. https://s-media-cache-ak0.pinimg.com/originals/aa/cf/1e/aacf1ea528d6c3463f3d1d6237aae885.jpg
https://s-media-cache-ak0.pinimg.com/originals/54/63/4d/54634dbafeed6593f244f51ffeed455e.jpg

9. http://naturemapr.blob.core.windows.net/img-content-custom/2459421.jpg?r=2016224114333

10. http://naturemapr.blob.core.windows.net/img-content-custom/2459421.jpg?r=2016224114333

11. http://museumvictoria.com.au/bioinformatics/snake/images/textlive6.jpg

12. https://strathbogierangesnatureview.wordpress.com/snap/fauna/reptiles-of-the-strathbogie-tableland/cimg9416/

13. https://goulburnbrokendelmaimpar.wordpress.com/author/bertbohosouth/(Maindample)

14.https://www.flickr.com/photos/gondwanareptileproductions/8650407337/in/album-72157632441252854/

15. http://user-generated-content.natureshare.org.au/observations/photos/original/ 53b3985de35eb12984011400.jpg?1404500871

16. http://media.bowerbird.org.au/88/87911-Constrained600.jpg

bases do insist on locality data, there is still a paucity of records even for many common reptile species. The omission of locality data accompanying photographs is a criticism also applicable to a number of print publications (both recent and historical).

Conclusions

From the sample of banded *P. t. textilis* examined, the following conclusions are drawn concerning body banding patterns:

1. The number of body bands which juveniles possessed varied from 2 to approximately 90.
2. Juveniles from Victoria typically had a smaller number of body bands (≤ 55) compared to those from NSW (55+), though there was some overlap.
3. Body bands were typically 1–2 dorsal scale lengths wide; the head patch and nape band were typically separated or narrowly in contact and most juveniles did not exhibit posterior fading of body bands.
4. Juveniles that lacked body bands were apparently more common across most of the species' range than banded juveniles, but quantitative data is limited to a small number of localities and based on relatively small sample sizes.
5. Juveniles with incomplete body bands have been recorded from multiple localities in Victoria and NSW.

The generality of some conclusions is questionable because of the small sample size. It is hoped, therefore, that this review will encourage other naturalists to document the occurrence of banded *P. t. textilis* (with locality data) so that the full extent of the variation and geographic trends in banding patterns may be more reliably determined.

Acknowledgements

Thanks to John Fowler for providing information about the SA specimen, Prof. Mike Lee (University of Adelaide/South Australian Museum) for providing me with several references, and the anonymous referees for improvements to the manuscript.

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Received 3 March 2016; accepted 4 August 2016

Surveys of vertebrate fauna of the Eumeralla section of the Great Otway National Park, Victoria, 2004 – 2015. 1. Mammals

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Abstract

Surveys of vertebrate fauna of the Eumeralla section of the Great Otway National Park in southern Victoria were carried out between March 2004 and March 2015. Twenty species of mammals were recorded, including several species listed as threatened or near threatened under Victorian and Federal legislation. These were Southern Brown Bandicoot *Isoodon obesulus obesulus*, Swamp Antechinus *Antechinus minimus maritimus*, White-footed Dunnart *Sminthopsis leucopus* and Eastern Pygmy Possum *Cercartetus nanus*. Results from these surveys show the importance of long-term studies and confirm high biodiversity for this section of this important national park. (*The Victorian Naturalist*, 134 (1), 2017, 11–18)

Keywords: Bandicoot, Antechinus, Dunnart, Pygmy Possum, rainfall, biodiversity

Introduction

The Eumeralla section of the Great Otway National Park (Eumeralla) (38°23' S, 144°12' E) is situated approximately 90 km south-west of the Melbourne CBD, near the coastal town of Anglesea in southern Victoria (Fig. 1). Surveys of mammals, reptiles and amphibians were conducted at the site from March 2004 to 2015 (Homan 2015). The surveys were conducted by staff from Royal Melbourne Institute of Technology (RMIT) University and Holmesglen Institute, and students who were studying for the Diploma of Conservation and Land Management. RMIT conducted 12 surveys in early autumn of each year (first week in March each year, except for last week in February 2006) from 2004 to 2015 and four surveys in spring (October 2006, September 2007, October 2009 and September 2013). Holmesglen Institute conducted eight surveys in spring of each year (September or October) from 2006 to 2013 with one additional survey in May 2013. Another survey was conducted in June 2006 by members of the Fauna Survey Group of the Field Naturalists Club of Victoria as part of the club's training program. For the purposes of this paper the February and June surveys mentioned above have been included in the autumn surveys.

The purposes of the surveys were:

1. To determine the continuing presence and relative abundance of mammals, reptiles and amphibians, including several threatened species, in this section of the national park. The land manager, Parks Victoria, was to use these data for planning control burns and management of threatened species.
2. To provide structured training for students in fauna survey techniques.

Study Site

The Great Otway National Park (GONP) covers 103 185 ha and stretches in various sections from Point Addis in the east to Princetown in the west. The Eumeralla section, which covers approximately 400 ha, is located in the far-east-

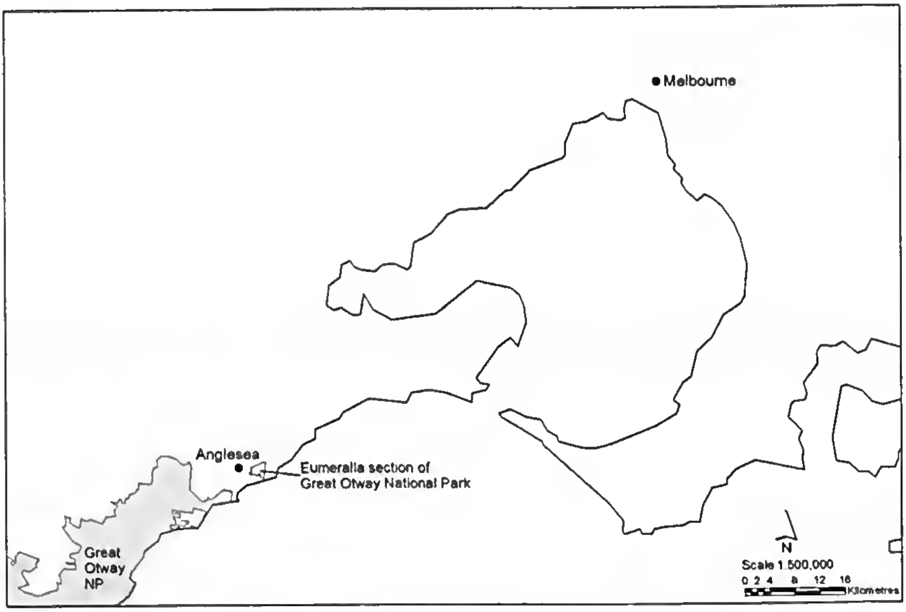

Fig. 1. Map showing location of Eumeralla section of Great Otway National Park in Victoria.

ern area of the park within the Otway Plain bioregion. This part of the park is somewhat isolated and is bordered to the south by Bass Strait, to the west by the adjoining Eumeralla Scout Camp (with many roads and buildings), to the north by the Great Ocean Road and to the east by areas of private land with fragmented indigenous vegetation. This section of the park was previously the Eumeralla Flora Reserve. The study site covered approximately six ha and was situated on the western edge of the national park adjacent to the scout camp. The study site was previously part of the adjoining scout camp. Important areas of vegetation within the scout camp were incorporated into the national park when the park was proclaimed in 2005. Numerous studies of small mammal populations have been conducted in the heathlands and heathy woodlands of the eastern Otways region (Conole and Baverstock 1983; Wilson and Moloney 1985; Wilson *et al.* 1986; Laidlaw and Wilson 1989; Wilson *et al.* 1990; Laidlaw and Wilson 1996; Laidlaw *et al.* 1996; Wilson *et al.* 2001; Gibson *et al.* 2004; Magnusdottir *et al.* 2008; Sale *et al.* 2008). However, previous studies did not include the current study site. The major part of this section of the national park, including the study site, was severely burnt by the Ash Wednesday wildfire in February 1983.

Vegetation and topography

The Ecological Vegetation Class is Heathy Woodland (EVC 48). The study site comprises a gentle south-south-westerly slope with sandy soil above a wide, shallow gully. The vegetation in the gully and up to 100 m above the gully is dense up to 2 m high. A fire dam exists in the gully. The central point of the site is 60 m above sea level. Dominant species include Messmate *Eucalyptus obliqua*, Brown Stringybark *Eucalyptus baxteri*, Austral Grass Tree *Xanthorrhoea australis*, Silver Banksia *Banksia marginata*, Prickly Tea-tree *Leptospermum continentale*, Heath Tea-tree *Leptospermum myrsinoides*, Common Flat-pea *Platylobium obtusangulum*, Scrub She-oak *Allocasuarina paludosa*, Thatch Saw-sedge *Gahnia radula*, Austral Bracken *Pteridium esculentum* and Common Rapier-sedge *Lepidosperma filiforme*.

Methods

Survey techniques included Elliott trapping, Type A (Elliott Scientific Equipment, Upwey, Victoria), cage trapping (Wiretainers Pty Ltd, Preston, Victoria; RE Walters 1899 Pty Ltd,

Sunshine, Victoria), pitfall trapping, remote surveillance cameras (Scoutguard, Models: SG550V and KG680V, China), harp trapping (Ecological Consulting Services, Newport, Victoria; Faunatech, Bairnsdale, Victoria) and general observation. Elliott and cage traps were set in grids containing up to 10 lines of traps, with four cages and six Elliotts on each line. Trap lines were 30 m apart and traps were set 10 m apart along each line. Elliott and cage traps were closed during the day. Baits for Elliott traps consisted of quick oats, smooth peanut butter and honey or golden syrup. Sardines were added to this mixture for cage trap baits.

Five pitfall lines were established, each containing 10, 20 L plastic buckets spaced at 5 m intervals, with a 30 cm high aluminium flywire drift fence that stretched for 55 m. One or two pitfall lines were used on each survey and were left open for day-time and night-time sampling.

Due to the risk of flooding, Elliott traps, cages and pitfalls were not set in the gully mentioned above. Surveillance cameras were set approximately 50 m apart throughout the lower parts of the survey site, with the majority set close to, or in the gully. Baits for cameras were the same as for Elliott traps. Cameras were used only after October 2009 and two to six cameras were used on each survey. Harp traps were set across a four-wheel-drive track which ran parallel and close to the gully. One or two harp traps were used on each survey. Overall, 7920 trap-nights were completed (Table 1).

Results

Twenty species of mammals were recorded, of which one was a monotreme, eight were marsupial and eleven were eutherian (Table 2). Seventeen species were native and three were introduced. Several species listed as threatened or near-threatened were recorded. These were Southern Brown Bandicoot *Isoodon obesulus obesulus* (Fig. 2), Swamp Antechinus *Antechinus minimus maritimus* (see front cover), White-footed Dunnart *Sminthopsis leucopus* and Eastern Pygmy Possum *Cercartetus nanus*.

Table 1. Survey methods and effort (trap-nights) completed for autumn and spring surveys.

	Elliott	Cage	Pitfall	Harp	Camera	Total
Autumn surveys	2675	1457	445	36	104	4717
Spring surveys	1711	1086	311	38	57	3203

Table 2. List of mammals and number recorded. E = estimated number.
T indicates threatened species; NT indicates near-threatened species; * indicates introduced species.

Common Name	**Scientific Name**	**Number**	
		Autumn	**Spring**
Short-beaked Echidna	*Tachyglossus aculeatus*	5	10
Agile Antechinus	*Antechinus agilis*	86	23
Swamp Antechinus	*Antechinus minimus maritimus*, T	24	6
White-footed Dunnart	*Sminthopsis leucopus*, T	1	4
Southern Brown Bandicoot	*Isoodon obesulus obesulus*, T	48	19
Eastern Pygmy Possum	*Cercartetus nanus*, NT	4	2
Common Ringtail Possum	*Pseudocheirus peregrinus*	10	2
Eastern Grey Kangaroo	*Macropus giganteus*	68	27
Black Wallaby	*Wallabia bicolor*	22	16
White-striped Freetail Bat	*Tadarida australis*	10E	
Gould's Wattled Bat	*Chalinolobus gouldii*	5	
Chocolate Wattled Bat	*Chalinolobus morio*	6	1
Southern Forest Bat	*Vespadelus regulus*	1	
Little Forest Bat	*Vespadelus vulturnus*	15	6
Lesser Long-eared Bat	*Nyctophilusgeoffroyi*	71	51
House Mouse	*Mus musculus* *	25	
Swamp Rat	*Rattus lutreolus*	123	97
Bush Rat	*Rattus fuscipes*	104	62
Red Fox	*Vulpes vulpes* *	2	
European Rabbit	*Oryctolagus cuniculus*	4	4

Fig. 2. Southern Brown Bandicoot *Isoodon obesulus obesulus*.

Discussion

Results from these surveys produced records of a wide range of mammals with populations persisting throughout the study period. The Agile Antechinus and the native rodents (Bush Rat and Swamp Rat) are common and widespread in suitable habitat throughout much of southern Victoria (Menkhorst 1995). At Eumeralla mean capture rates for these species were 3.4%, 2.3% and 3% respectively for autumn surveys and 1.4%, 1.9% and 3.3% for spring surveys. The six species of insectivorous bats recorded at Eumeralla are all common throughout much of Victoria (Menkhorst 1995). The Lesser Long-eared Bat is one of Australia's most abundant mammals and is common and widespread in all regions of Victoria (Menkhorst and Knight 2011). At Eumeralla this species made up between 75% and 100% of bat captures on fourteen occasions (six in autumn; eight in spring).

The Southern Brown Bandicoot inhabits heathlands, heathy woodlands and heathy forests across southern Victoria in a fragmented distribution (Menkhorst 1995). The species has disappeared from previous strongholds, especially in Melbourne's south-eastern suburbs (Seebeck 1977; Menkhorst and Seebeck 1990; Coates *et al.* 2008); however, good populations persist in areas such as East Gippsland Lowlands, Wilsons Promontory, Greater Grampians, Glenelg Plain, Warrnambool Plain and the eastern Otway Plain. Due to a number of major threats, including changed fire regimes and predation by the Red Fox (Brown and Main 2010), the species is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* (*FFG Act 1988*) (DELWP 2015) and as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*). The species is also listed as near threatened in Victoria (DSE 2013).

Capture rates for Southern Brown Bandicoots across Victoria have often been low (Callanan and Gibson 1977; Menkhorst and Beardsell 1982; Rees and Paull 2000; Homan 2007; Homan 2008). Previous mammal surveys in the Otways region have also produced low capture rates (Conole and Baverstock 1983; Wilson *et al.* 1986; Laidlaw and Wilson 1989; Hill

and Homan unpubl.). At Eumeralla the mean capture rate was 2.9% for autumn surveys (n = 14) and 1.7% for spring surveys (n = 12). However, on three occasions during autumn surveys capture rates were considerably higher. Five captures occurred in March 2005 (all in cage traps, 4.6%), nine captures in February 2006 (all in cage traps, 8.3%) and 18 captures in March 2011 (12 in cage traps, 10%; six in Elliott traps, 6% for cages plus Elliott traps). These spikes in capture rates coincided with above average rainfall for the general coastal area during the previous August, September and October (Table 3). The high capture rates in 2005 and 2006 also occurred during a program of fox baiting that was carried out from April 2004 until March 2006 on a voluntary basis by local community members (S Carmichael unpubl.). Several studies have shown that fox baiting has a positive impact on populations of Southern Brown Bandicoots (Dexter and Murray 2009; Robley *et al.* 2009; Homan and Schultz 2012). However, to be successful in fragmented landscapes, fox baiting needs to be carried out frequently over thousands of hectares (Robley 2010). Whilst fox baiting at Eumeralla may have been beneficial to some extent, it is more likely that the above average rainfall of the previous spring, combined with high quality habitat, was the main reason for high abundance in 2005 and 2006. Results from March 2011 suggest that the very high rainfall during the previous spring produced ideal conditions for breeding of Southern Brown Bandicoots. The very high capture rate in 2011 also followed the breaking of a severe and lengthy drought. However, a study in coastal vegetation in the Nadgee Nature Reserve in southern New South Wales, 28 years post-wildfire, found that habitat structure rather than rainfall was more important for maintenance of Southern Brown Bandicoot populations (Arthur *et al.* 2012).

The Southern Brown Bandicoot is generally considered to be a seasonal breeder in most of the areas occupied by the species in Victoria (Menkhorst 1995). During a study at Cranbourne, south-east of Melbourne, pouched young were first observed during August and were last seen in December over a two year period (Lobert and Lee 1990). In the southern Grampians National Park pouched young were recorded in early October (Homan and Schultz 2012). In the Black Range near Stawell, over several years, pouched young were recorded in August, late February and early March (Homan 2005). In the Wonthaggi Heathlands Nature Conservation Reserve, in South Gippsland, pouched young were recorded in September (Homan 1999). At Eumeralla during autumn surveys, pouched young were recorded on one occasion in March 2005 and on two occasions in February 2006. During spring surveys one female with pouched young was recorded in October 2009, one in October 2011 and two in October 2012.

In recent times surveillance cameras have become a standard survey method for detecting the presence of many terrestrial mammals (Meek and Fleming 2014). At Eumeralla, surveillance cameras were used on 14 occasions from October 2009 to March 2015 (seven in autumn and seven in spring) for 161 camera-nights; yet Southern Brown Bandicoots were recorded by cameras on only three occasions. In March 2011, following the breaking of the drought, 18 Southern Brown Bandicoots were captured over three nights, yet six surveillance cameras, all set in typical bandicoot habitat for three nights during this survey, failed to detect the species. These results suggest that a range of survey techniques should be used when surveying for the presence of species, especially taxa that are considered cryptic. Other species recorded by surveillance camera were

Table 3. Late winter/early spring rainfall records for Airey's Inlet/Anglesea area of coastal Victoria. Source: Australian Bureau of Meteorology. Units = millimetres; HM = Historical mean.

	HM	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
August	66.4	90	86.2	33	41.8	66.6	104	115	36.4	60	97.4	48.8
September	55.8	63.6	74.8	42	42	35.2	79.2	60.4	33.4	46.4	63.4	26.2
October	59	80.4	71.2	17.6	26	9.6	54.8	117	74.6	33	101.4	20.2

Short-beaked Echidna, Agile Antechinus, Eastern Grey Kangaroo, Black Wallaby, Bush Rat, Swamp Rat and Red Fox.

The Swamp Antechinus inhabits dense wet heath and heathy woodland, sedgeland and tussock grassland (Menkhorst and Knight 2011). In Victoria the distribution of the species is mostly coastal, stretching from Sunday Island in Gippsland to the far south-west of the state (Menkhorst 1995). Most populations of the Swamp Antechinus are isolated and are at risk from several impacts, including wildfire and introduced predators (Menkhorst 1995). The Swamp Antechinus is listed therefore as threatened under the *FFG Act 1988* (DELWP 2015) and vulnerable under the *EPBC Act 1999*. The species is also listed as near threatened in Victoria (DSE 2013).

Previous mammal surveys in the Otways region have produced low capture rates for the species (Conole and Baverstock 1983; Wilson *et al.* 1986; Laidlaw and Wilson 1989). During a major mammal survey in February 2014 in the Carlisle heathlands on the northern edge of the Otway ranges, the capture rate for Swamp Antechinus was zero at two sites, 0.9% at three sites and 3.5% at one site (Hill and Homan unpubl.). At Eumeralla the highest capture rate of 2.6% occurred in Autumn 2005 following above average rainfall in the previous winter and spring. Other studies have found that rainfall has a major effect on populations of Swamp Antechinus (Magnusdottir *et al.* 2008; Sale *et al.* 2009). At Anglesea, peak abundance was observed following the highest annual rainfall for two decades (Magnusdottir *et al.* 2008). However, at Eumeralla, no captures occurred over a five year period between March 2007 and March 2012, despite above average rainfall during the latter part of this period. During spring surveys the species was recorded on two occasions only (2.5% October 2006 and 0.5% October 2012). Wilson *et al.* (2001) conducted a study of the distribution and ecology of Swamp Antechinus at a number of sites in the eastern Otways. During that study all records of the species were obtained from within 10 m of a gully and from gentle, southerly slopes. At Eumeralla, 80% of Swamp Antechinus captures occurred on the sandy slope between 20 m and 80 m above the gully in areas of dense vegetation up to two metres high. The remaining 20% occurred up to 140 m above the gully in more open vegetation. Surveillance cameras set close to, and in the gully, failed to detect Swamp Antechinus.

In Victoria, the White-footed Dunnart is found along the coast and a number of inland areas especially in east Gippsland and the central highlands (Menkhorst 1995). However, populations of the White-footed Dunnart are at risk from a number of factors including loss, fragmentation and degradation of habitat and the species is therefore listed as threatened under the *FFG Act 1988* (DELWP 2015). The species is also listed as near threatened in Victoria (DSE 2013). Capture rates are usually low (Cheetham and Wallis 1981) and studies in the eastern Otways have also produced either no records or low capture rates for the species (Conole and Baverstock 1983; Wilson *et al.* 1986; Laidlaw and Wilson 1989; Laidlaw *et al.* 1996). At Eumeralla, White-footed Dunnarts were recorded during five surveys only, with one adult female (no pouched young) in September 2007; one adult male in September 2008; two in October 2009 (one adult male and one adult female with three pouched young); and one adult male in March 2011.

The five White-footed Dunnarts recorded were all captured in Elliott traps; however, pitfall trapping commonly produces records of this species. At the Wonthaggi Heathlands a pitfall trapping survey between February 2001 and February 2002, designed to determine the presence of reptiles and amphibians (Homan 2003), produced 31 captures of White-footed Dunnarts (745 pitfall trap-nights). Cheetam and Wallis (1981) suggested that a range of techniques including pitfall trapping may help to determine the conservation status of White-footed Dunnart. Bennett *et al.* (1988) found that pitfall trapping was especially useful for recording White-footed Dunnart during studies in three regions of Victoria. Despite the completion of 756 pitfall trap-nights at Eumeralla between 2004 and 2015, this survey method was unsuccessful in recording this species.

The Eastern Pygmy Possum is found in a wide range of vegetation communities across much of southern and central Victoria (Harris and Goldingay 2005). Due to a number of threats

including habitat loss, changed fire regimes and predation from introduced predators, the species is recognised as near threatened in Victoria (DSE 2013). The Eastern Pygmy Possum is omnivorous, but feeds extensively on pollen and nectar from the families Proteaceae and Myrtaceae, especially from *Banksia* spp. (Turner 1984; Ward 1990). Harris (2010) studied the ecology of the species and found that captures were usually confined to areas with prolific flowering of potential food plants, especially *Banksia* spp. in late summer/early autumn. At Moyston West in western Victoria, the Eastern Pygmy Possum was recorded from pitfall trapping in early autumn following the prolific flowering of Silver Banksia *Banksia marginata* (Homan 2012). Laidlaw and Wilson (1996) conducted a radio tracking study of Eastern Pygmy Possums in coastal heathland near Anglesea; during their survey the highest capture rates occurred in late summer/early autumn 1992. At Eumeralla, Eastern Pygmy Possums were first recorded during autumn surveys in March 2011 (three individuals captured in Elliott traps) following the breaking of the drought and prolific flowering of Silver Banksia. Another individual was captured in a pitfall trap in March 2014 (Homan 2015). During spring surveys, the species was captured in pitfall traps only, one in October 2007 and one in September 2008. Harris (2010) suggested a range of techniques should be used when surveying for the presence of Eastern Pygmy Possum. Bennett *et al.* (1988) found that pitfall trapping was particularly useful for detecting Eastern Pygmy Possum.

Very few long-term surveys of vertebrate fauna are currently conducted in crown conservation reserves across Victoria. Surveys such as those conducted in the Eumeralla section of GONP provide important data on the ongoing presence and relative abundance of a wide range of taxa, especially rare and threatened species. The results provide the land manager with key data which are essential for important management decisions, especially controlled burns and management of threatened species. All species of mammals known historically from this area (Victorian Biodiversity Atlas) were recorded during the surveys between 2004 and 2015. Despite the severity of the Ash Wednesday wildfire, no mammal extinctions have occurred in the Eumeralla section. Other sections of GONP, with different vegetation communities, are well known to support diverse mammal communities (Menkhorst 1995). The results from the Eumeralla surveys confirm high mammal diversity for this section of this iconic national park and successful recolonisation following the wildfire of 1983.

Acknowledgements

The surveys were conducted under the terms of numerous research permits issued by the Department of Environment, Land, Water and Planning and approval from the Animal Ethics Committee of RMIT University and the Animal Ethics Committee of the Department of Primary Industries. Thanks to Parks Victoria, especially Emma Danby and Suzanna McCoy from the Anglesea office for access to the study site and guidance. Many thanks to the large number of past students from RMIT and Holmesglen who took part in the surveys. Special thanks to past and present staff from both institutes, especially Nevil Schultz, Bruce Partland, Graeme Eames, Peter Brown and Sebastian Buckingham. The map showing the location of the survey site was produced by Ben Imbery of Indigenous Design Land Management Pty Ltd, Research, Victoria using ArcMap. An anonymous referee made helpful suggestions that improved the manuscript.

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Received 12 May 2016; accepted 3 November 2016

The response of rare floodplain plants to an environmental watering event at Hattah Lakes, Victoria

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Abstract
In 2014 and 2015, botanical surveys were undertaken at Hattah Lakes, Hattah-Kulkyne National Park, in semi-arid north-western Victoria, to study the response of understorey vegetation to a strategic environmental watering event. During the surveys, 23 plant species listed on the Victorian Government Advisory List of Rare and Threatened Species were recorded; with two of these species also listed under the *Flora and Fauna Guarantee Act 1988* (Vic). Four of these species were recorded for the first time in the Park, and for a further 11 species the number of records were, at least, doubled within the Park. The 23 rare species represented five Water Plant Functional Groups. The cover of two functional groups and two species were significantly different before and after inundation. Although species and functional group responses to inundation differed, a key outcome from this study was the increase in rare species records for Hattah-Kulkyne National Park. (*The Victorian Naturalist*, 134 (1) 2017, 19–27)

Keywords: environmental watering, water plant functional groups, threatened flora

Introduction

The Hattah Lakes complex, which forms part of the Hattah-Kulkyne National Park (480 km^2), is located on the floodplain of the Murray River, in north-western Victoria (Murray-Darling Basin Authority (MDBA) 2012). It lies in the southern section of the Murray Basin, a major geological unit in south-eastern Australia that covers approximately 300 000 km^2 of New South Wales, Victoria and South Australia (White *et al.* 2003). Hattah Lakes is a semi-arid environment composed of a 13 000 ha complex of over 20 lakes (10 to 200 ha) and associated waterways and floodplains (Murray Darling Basin Authority (MDBA) 2012). Twelve lakes are listed under the Ramsar Convention as internationally important wetlands (Dept of Sustainability and Environment (DSE) 2003; MDBA 2012). The Hattah Lakes area is defined by the extent of the 1956 flood event, the largest known for the region (MDBA 2012).

Hattah Lakes has a long history of human occupation which has shaped the vegetation communities and their composition. For tens of thousands of years, the Murray River floodplain and the vegetation mosaic of Hattah Lakes sustained indigenous people, including the Latji Latji and Nyeri Nyeri people (Donati 2008). Many cultural sites exist within the Park, some of which have been dated to over 15 000 years old (DCNR 1996; Donati 2008).

Since European settlement, the vegetation has been altered by overgrazing, soil erosion, fire, water regulation and recreational activities (DCNR 1996). In 1847, James Crawford established 'Kulkyne', a 20 mile pastoral run, starting the pastoral industry which peaked in the 1860s (DCNR 1996; Donati 2008). At the same time (and later) the area was also heavily affected by the timber trade, producing fuel for paddle steamers and settlement (e.g. fence posts, housing; DCNR 1996, Donati 2008). In 1915, a native game reserve was created around some of the lakes and in 1924 the Kulkyne State Forest was established, incorporating most of the Crawford pastoral run (Donati 2008). Hattah Lakes National Park was established in 1960, with the state forest incorporated in 1980 to form the current Hattah-Kulkyne National Park (DCNR 1996).

The vegetation mosaic on the Hattah Lakes floodplain relies on occasional flooding (natural or environmental watering) to maintain ecosystem function and allow many plant species to complete their life cycles (e.g. germination, flowering). Diminished connec-

Fig. 1. Lake Bed Herbland at Lake Kramen.

tivity between the Hattah Lakes and Murray River, together with the extraction of water for agriculture, industry and urban use, and severe drought over the last decade, have negatively affected vegetation communities of the Hattah Lakes ecosystem that depend on flooding (MDBA 2012). As a result, the environmental health of the floodplain ecosystem and its habitat value for fauna and flora has declined (Cunningham *et al.* 2009). In 2005, a program of environmental watering was implemented to manage the reduced frequency of natural flooding and to inundate Hattah Lakes (MDBA 2009). The delivery of environmental water is seen as an important factor in the maintenance and improvement of ecosystem health and biodiversity values (DSE 2003; MDBA 2012).

In this study, we investigated the response of 23 rare plant species to an environmental watering event. Rare plant species were determined by their listing on the Victorian Department of Environment, Land Water and Planning (DELWP) Advisory List of Rare or Threatened Plant Species (2014). We compared their abundance before and after the watering event, and evaluated the responses of species associated with different water plant functional groups.

Methods

Study region

This study was undertaken in the Hattah Lakes system of Hattah-Kulkyne National Park (480 km^2) on the Murray River floodplain in northwestern Victoria. Ten Ecological Vegetation Classes (EVCs; White *et al.* 2003; MDBA 2012) occur across the park, three of which occur as a mosaic in areas that are intermittently flooded: Lake Bed Herbland, Intermittent Swampy Woodland and Riverine Chenopod Woodland.

Lake Bed Herbland is dominated by species adapted to drying mud within lake beds on floodplains (Fig. 1). This vegetation type has two distinct temporal stages: with photosynthetic vegetation and without photosynthetic vegetation (i.e. the species present occur only in the soil seed store), from open water to bare mud. Floods are intermittent but water may be retained for several seasons leading to active growth at the 'drying mud stage' (White *et al.* 2003). Intermittent Swampy Woodland has a canopy dominated by River Red Gum *Eucalyptus camaldulensis* (Fig. 2) and Eumong *Acacia stenophylla* and sometimes Black Box *E. largiflorens* and Tangled Lignum *Duma florulenta* with a variable shrubby and rhizomatous sedgy-turf grass ground stratum (White *et al.* 2003). The vegetation is dominated by flood-stimulated species, together with species tolerant of inundation. Flooding is unreliable but may be extensive (White *et al.* 2003). Riverine Chenopod Woodland has a canopy dominated by *E. largiflorens* above a characteristic chenopod shrub stratum. Commonly associated species include Nitre Goosefoot *Chenopodium nitrariaceum*, Nodding Saltbush *Einadia nutans*, Ruby Saltbush *Enchylaena tomentosa* var. *tomentosa* and Hedge Saltbush *Rhagodia spinescens*; *Acacia stenophylla* may also occur (White *et al.* 2003).

Study design

In April 2014, 20 sites were established and baseline floristic data were collected across 10 lakes (Fig. 3), prior to an environmental water-

Fig. 2. *Eucalyptus camaldulensis* at Lake Tullamook.

ing event. The aim of watering was to inundate the floodplain vegetation to 45 m elevation (ASL) (replicating a one-in-eight-year flood event; MBDA 2012) with a particular focus on targeting the treed plant communities and their associated network of permanent and semi-permanent wetlands. Eighty-eight gigalitres (GL) of water were delivered to the main lakes between 19 May and 11 September 2014, and 16 GL were delivered to Lake Kramen between 7 September 2014 and 18 January 2015. The sites were resurveyed in April 2015, following the watering event.

At each site, a transect running perpendicular to the lake edge of April 2014 onto the floodplain, was used to measure biological and environmental attributes across the elevation-moisture gradient. Nine of the surveyed lakes contained water in April 2014, while the tenth (Lake Kramen) did not. The lake edge in that instance was estimated based on vegetation composition and species that are known to colonise dry lake beds at Hattah-Kulkyne. Floristic information was recorded in 1 m^2 quadrats along either 50 m or 100 m transects (14 and 6 sites, respectively). Twenty-five 1 m^2 quadrats were surveyed along the 50 m transects and thirty 1 m^2 quadrats were surveyed along the 100 m transects. In addition, each 50 m transect had one 15 x 15 m quadrat and each 100 m transect had two 15 x 15 m quadrats. The percentage of live foliage projective cover of each vascular plant species in each quadrat (irrespective of size) was estimated to the nearest 5%.

Rare species were defined as those listed on DELWP's Advisory List of Rare and Threatened Species (2014). The Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* were also searched for additional rare species found during our surveys. The status of these species is recorded as 'poorly known', 'rare', 'vulnerable' or 'endangered' depending upon their risk of disappearing from wild populations. This risk is based on the number of populations, the area over which populations occur and/or their ability to return from disturbance, including natural events (e.g. drought, fire, flood, landslip; DELWP 2014). Plant taxonomy follows Walsh and Stajsic (2007).

Water Plant Functional Groups

We used Water Plant Functional Groups (e.g. Merritt *et al.* 2010; Casanova 2011; Campbell *et al.* 2014) to compare species' responses to

Fig. 3. Hattah-Kulkyne National Park and Murray Kulkyne, highlighting the ten lakes surveyed in this study.

watering. These functional groups are based on how species respond to flood events and their water requirements over their lifetime (Brock and Casanova 1997). Five functional groups (Brock and Casanova 1997; Casanova 2011; Campbell *et al.* 2014) were considered here.

Terrestrial dry (Tdr) species are essentially terrestrial plant species which do not require flooding, but will germinate in damp soil following a flood event. They may invade riparian zones and wetland edges if these remain dry for an extended period (e.g. episodic lakes; Casanova 2011). We expect the response of terrestrial dry species to environmental watering to be variable. That is, species may disappear from areas inundated too long (e.g. the soil seed bank cannot withstand prolonged inundation) but may increase in areas where inundation is short (e.g. leaving the soil seed bank intact and the soil suitably damp for germination).

Terrestrial damp (Tda) species may germinate following flooding or high rainfall and need the soil to remain damp for approximately three months. They cannot tolerate flooding but exist in dried up puddles, drainage lines and wetland edges (Casanova 2011). We expect terrestrial damp species to be present in any year if there has been sufficient rainfall to provide damp soil in which they can germinate, and limited flooding while they are in their vegetative state.

Amphibious fluctuation responder – plastic (ARp) species respond to changes in water levels morphologically; for example, rapid growth, and are able to survive on damp and drying soil (Casanova 2011).We expect amphibious responder species present in the soil seed bank to germinate in response to an environmental watering event.

Amphibious fluctuation tolerators – low-growing (ATl) species can germinate on either saturated soil or under water but must be above water in order to flower and set seed (Casanova 2011). We expect low-growing amphibious tolerator species to be present aboveground both before and after an environmental watering event, although they may be more common after inundation as they require shallow flooding for approximately three months.

Amphibious fluctuation tolerators – emergent (ATe) species can survive in saturated soil or shallow water but most of the plant must be above water (Casanova 2011). We expect emergent amphibious tolerator species to be present before and after the environmental watering event, although they may be more common after inundation as they need water to be present for approximately 8 to 10 months of the year.

Data analysis

We searched the Victorian Biodiversity Atlas (VBA; DELWP 2015) for previous records of rare species within Hattah-Kulkyne National Park, to determine how many additional records our study added. The quadrat data (1 m^2 and 15 x 15 m) were used to determine the total number of records for each of the rare species recorded. Each quadrat occurrence was counted as one record.

Each rare species was allocated to a Water Plant Functional Group (Brock and Casanova 1997; Casanova 2011; Campbell *et al.* 2014). For species not allocated to a functional group by Campbell *et al.* (2014), we followed the key in Casanova (2011) to allocate species to an appropriate group.

Wilcoxon signed rank tests in R 3.2.3 (R Core Team 2015) were used to investigate if there was a difference in species or functional group cover before and after the environmental watering event. Wilcoxon tests were run for emergent amphibious tolerator, terrestrial damp and terrestrial dry functional groups comparing paired quadrats for each species before and after the watering event. Unlike the number of records, here we considered only the 1 m^2 quadrats. To be included in the analysis, species had to be present in each quadrat in only one year. Amphibious responders and low-growing amphibious tolerators were not tested because only one species (*Ammannia multiflora, Centipeda nidiformis* respectively) was present in each of these functional groups. *Ammannia multiflora* was present only in 2015 and *Centipeda nidiformis* in less than 10 quadrats across both years, thus a meaningful comparison could not be made between the years. In order for a species to be analysed it had to have at least 10 records within the 1 m^2 quadrats across both years. Of the 23 rare species, Wilcoxon tests were carried out for five species (*Alternanthera* sp. 1 (Plains), *Calotis cuneifolia, Cyndon dactylon* var. *pulchellus, Eragrostis lacu-*

naria, Phyllanthus lacunellus). For the remaining 18 species, there were either <10 records from both years or the species was present in one year only, thus meaningful statistical comparisons could not be made.

Results

The surveys resulted in 319 records of 23 rare species, in the Hattah Lakes system (Table 1). Four species (*Alternanthera* sp. 1 (Plains), *Cardamine moirensis, Crinum flaccidum, Cyperus squarrosus*) were recorded for the first time within Hattah-Kulkyne National Park. Eleven species were recorded in both survey years, while 12 species were recorded only in 2014 or 2015 (Table 1). Of the 23 species, five are poorly known, eight are rare, nine are vulnerable and one is listed as endangered (DELWP 2014). Two species, *Crinum flaccidum* (vulnerable) and *Cyperus rigidellus* (endangered), are listed under the FFG Act.

The 23 rare species occurred across five functional groups (Table 1). Two of these groups were represented by one species each, amphibious responders (*Ammannia multiflora*) and low-growing amphibious tolerators (*Centipeda nidiformis*). Emergent amphibious tolerators were represented by four species (*Cyperus rigidellus, Cyperus squarrosus, Isolepis australiensis, Lipocarpha microcephala*). The dominant functional groups were terrestrial dry (11 species) and terrestrial damp (six species).

Terrestrial dry species exhibited a significant difference before and after the watering event with cover generally higher in 2014 (Table 2). Individually, the 11 terrestrial dry species showed variable responses to the environmental watering event with two species (*Lotus australis* var. *australis, Sida fibulifera*) present in 2014 only. In the case of *L. australis* var. *australis* the single site at which it was present in 2014 was still inundated in 2015. Another three species (*Atriplex lindleyi* subsp. *lindleyi, Triraphis mollis, Wahlenbergia tumidifructa*) were present only in 2015. The remaining six species (*Calotis cuneifolia, Cynodon dactylon* var. *pulchellus, Eragrostis lacunaria, Phyllanthus lacunellus, Sclerolaena patenticuspis, Swainsona microphylla*) were present in both years. Of these six species, the cover of *Calotis cuneifolia* was significantly higher before the watering event (2014) while the cover of *Phyllanthus lacunellus* was higher following the watering event (2015; Table 2).

The covers of terrestrial damp species were significantly higher in 2014 prior to the watering event (Table 2). Individually the six terrestrial damp species showed different responses to the environmental watering event, with *Bergia trimera* and *Rorippa eustylis* present only in 2014 and *Cardamine moirensis* present only in 2015. The remaining three species (*Alternanthera* sp. 1 (Plains), *Austrobryonia micrantha* (Fig. 4), *Crinum flaccidum*) were present in both years with the presence of *Crinum flaccidum* similar in both years, while the other species fluctuated. *Alternanthera* sp. 1 (Plains) exhibited a significantly higher cover before the watering event (2014; Table 2).

Ammannia multiflora (amphibious responder) was recorded at one site only following the watering event. *Centipeda nidiformis* (low-growing amphibious tolerator) was recorded in more quadrats following the environmental watering event than before it (6 vs. 2 quadrats) and at an additional two sites following inundation. Two of the four emergent amphibious tolerator species (*Cyperus rigidellus* and *Cyperus squarrosus*) were present in 2014 only, and one (*Isolepis australiensis*) in 2015 only. The fourth species (*Lipocarpha microcephala*) was present in both years.

Fig. 4. Mallee Cucumber *Austrobryonia micrantha* at Lake Woterap.

Table 1. Rare plant species recorded during botanical surveys at Hattah-Kulkyne National Park including the number of records from the Victorian Biodiversity Atlas (VBA) and from the current study. Species in bold are new records for Hattah-Kulkyne National Park.

Year recorded	Scientific name	Common name	Water plant functional group[1]	VIC ADV[2]	Number of records within Hattah		
					VBA	This study	Updated total[3]
Both	***Alternanthera* sp. 1 (Plains)**	Plains Joyweed	Tda	k	0	20	20
2015	*Ammannia multiflora*	Jerry-jerry	ARp	v	2	2	4
2015	*Atriplex lindleyi* subsp. *lindleyi*	Flat-top Saltbush	Tdr	k	5	2	7
Both	*Austrobryonia micrantha*	Mallee Cucumber	Tda	r	2	13	15
2014	*Bergia trimera*	Small Water-fire	Tda	v	2	4	6
Both	*Calotis cuneifolia*	Blue Burr-daisy	Tdr	r	8	72	80
2015	***Cardamine moirensis***	Riverina Bitter-cress	Tda	r	0	1	1
Both	*Centipeda nidiformis*	Cotton Sneezeweed	ATl	r	1	8	9
Both	***Crinum flaccidum***	Darling Lily	Tda	v *	0	10	10
Both	*Cynodon dactylon* var. *pulchellus*	Native Couch	Tdr	k	2	16	18
2014	*Cyperus rigidellus*	Curly Flat-sedge	ATe	e *	1	3	4
2014	***Cyperus squarrosus***	Bearded Flat-sedge	ATe	v	0	6	6
Both	*Eragrostis lacunaria*	Purple Love-grass	Tdr	v	34	30	64
2015	*Isolepis australiensis*	Inland Club-sedge	ATe	k	1	15	16
Both	*Lipocarpha microcephala*	Button Rush	ATe	v	19	9	28
2014	*Lotus australis* var. *australis*	Austral Trefoil	Tdr	k	1	1	2
Both	*Phyllanthus lacunellus*	Sandhill Spurge	Tdr	r	7	71	78
2014	*Rorippa eustylis*	Dwarf Bitter-cress	Tda	r	8	1	9
Both	*Sclerolaena patenticuspis*	Spear-fruit Copperburr	Tdr	v	3	9	12
2014	*Sida fibulifera*	Pin Sida	Tdr	v	12	5	17
Both	*Swainsona microphylla*	Small Leaf Swainsona-pea	Tdr	r	150	15	165
2015	*Tripalis mollis*	Needle Grass	Tdr	r	5	1	6
2015	*Wahlenbergia tumidifructa*	Mallee Annual-bluebell	Tdr	r	1	5	6

1: water plant functional groups are: ARp – Amphibious fluctuation responder – plastic, ATl – Amphibious fluctuation tolerator – low-growing, ATe – Amphibious fluctuation tolerator – emergent, Tda – Terrestrial damp and Tdr – Terrestrial dry. 2: species status codes are: r – rare, v – vulnerable, e – endangered and k – poorly known (DELWP 2014). 3: updated total number of records for Hattah (i.e. VBA + this study). * indicates species also listed under the *Flora and Fauna Guarantee Act* 1988.

Table 2. The relationship between the environmental watering event and water plant functional group and species cover. Significant results are shown in bold and comparisons not undertaken due to limited records are not shown.

Water plant functional group	Plant species	V	*p*
Terrestrial dry		**8652**	**0.01**
	Calotis cuneifolia	**536**	**<0.0001**
	Cynodon dactylon var. *pulchellus*	42.5	0.33
	Eragrostis lacunaria	179.5	0.93
	Phyllanthus lacunellus	**630**	**0.05**
Terrestrial damp		**462**	**<0.0001**
	***Alternanthera* sp. 1 (Plains)**	**171**	**0.0002**
Amphibious fluctuation tolerator – emergent		83.5	0.43

Discussion

The environmental watering event in late 2014 simulated a one in eight year flood event. Overall expectations were that vegetation community condition would improve (e.g. increased canopy health), flood respondent species would germinate and the abundance of species would increase as a result of increased soil moisture post-inundation. Water plant functional groups can be used as a means to predict how plant functional groups as a whole and individual species will respond to flooding (natural or otherwise). Generally, we would expect species in the five functional groups (terrestrial dry, terrestrial damp, amphibious responders, low-growing amphibious tolerators, emergent amphibious tolerators) to be present before and after the watering event. Their presence aboveground before and after would be dictated by available soil moisture and, for the amphibious tolerators, presence of shallow water. In addition, the length of inundation may influence how some species survive the watering event and whether those species in the soil seed bank are triggered to germinate.

Vegetation surveys prior to the environmental watering event detected 16 rare species in four functional groups (terrestrial dry, terrestrial damp, both amphibious tolerators). Following the watering event, an additional seven rare species were recorded, including one species in an additional functional group (amphibious responders). Of the 16 species recorded in 2014, 11 were still present in 2015 while the remaining five species were no longer present in the above-ground vegetation. There was considerable variability in how species within each functional group responded to the watering event.

Both terrestrial dry and terrestrial damp species showed variable responses to the environmental watering event. While species of both groups respond to increased soil moisture following flooding or high rainfall, they cannot tolerate flooding for extended periods of time (Casanova 2011). Three terrestrial dry species (*Atriplex lindleyi* subsp. *lindleyi*, *Triraphis mollis*, *Wahlenbergia. tumidifructa*) were present in 2015 only, in quadrats which were inundated during the environmental watering event, suggesting they may have germinated in response to increased soil moisture resulting from inundation. *Bergia trimera* and *R. eustylis* (terrestrial damp) were present in 2014 and not 2015, suggesting the above average rainfall (Bureau of Meteorology 2015) in the 12 months preceding the April 2014 surveys was sufficient to trigger germination of these species. In addition, terrestrial species lack tolerance for extended periods of inundation (Casanova 2011) and this may be the reason for their absence in 2015, as the quadrats in which *B. trimera* and *R. eustylis* were present were inundated for approximately 2–3 months during the environmental watering event. Furthermore, the presence of terrestrial species following the watering event may be a result of the interaction between inundation and site specific factors (e.g. soil type and moisture, competition from more robust species, presence in the soil seed bank, other

disturbances) plus the inherent rareness of suitable habitat for these species (Casanova and Brock 2000; Capon 2003; Raulings *et al.* 2010).

The amphibious functional groups have slightly different responses to inundation, with amphibious responders responding morphologically (Casanova 2011), and the two amphibious tolerator groups germinating in response to inundation. Thus, we expected amphibious responder species to germinate from the soil seed bank following inundation and the two tolerator groups to be more common following inundation as they require water to be present for extended periods of time (Casanova 2011). Both the single amphibious responder (*Ammannia multiflora*) and low-growing amphibious tolerator (*Centipeda nidiformis*) were more common following the environmental watering event than before it, suggesting inundation triggered germination. Nevertheless, this interpretation should be treated with caution as *A. multiflora* was present at only one site.

Emergent amphibious tolerators were more variable in their response to the environmental watering event. Two species (*Cyperus rigidellus, Cyperus squarrosus*) were present in 2014 but not 2015. As we expected emergent amphibious tolerators to be present in both wet and dry years, it was an unexpected result to 'lose' these two species from the landscape following the watering event as we would have expected them to increase in abundance. While these species require water for approximately 8 to 10 months of the year (Casanova 2011), it is possible that the period of submergence was too long for *C. rigidellus* and *C. squarrosus* to survive. There are also other factors that may have contributed to this result, such as seed presence or absence in the soil seed bank, other unknown germination triggers, competition from more robust species and the inherent rareness of suitable habitat. *Lipocarpha microcephala* was present at two of three sites in both years with a strong increase in cover at one of those sites (2% to 12% cover) indicating a response to the environmental watering event.

Water plant functional groups provide a useful tool to examine species' responses and make predictions as to how species within the groups will respond to an environmental watering event. While our expectations were broadly met, there was also much variation between individual species in each group. This is not an unusual outcome and highlights the need to appreciate that local influences may differ widely, affecting how species react to an environmental watering event. In addition, limitations associated with studying rare species often result in a paucity of data, as was the case with some species in this study. While functional group and species responses to the environmental watering event differed, a key outcome from this study was the increase in rare species records for Hattah-Kulkyne National Park.

Acknowledgements

This work was commissioned and funded by the Mallee Catchment Management Authority through the Federal Government's The Living Murray Initiative. The authors would like to thank Andrew Greenfield (Mallee Catchment Management Authority) and Parks Victoria (Hattah-Kulkyne National Park) staff, in particular Shane Southon and Damian Kerr. Doug Frood assisted with plant identification in 2014. David Cameron and Neville Walsh assisted with plant identification in 2015. Brad Farmilo and Garry Cheers assisted with field work in 2015. Mike Duncan, Brad Farmilo, Matt White, Andrew Bennett and David Cheal provided comments on earlier versions of the manuscript that greatly improved readability.

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Received 28 April 2016; accepted 6 October 2016

One Hundred and Two Years Ago

Wanderings on the Murray Flood-Plain

BY J G O'DONOHUE

(*Read before the Field Naturalists' Club of Victoria, 8th Feb., 1915*)

Lake Mournpoul is one of a series of comparatively shallow lake basins, some of which are of considerable area, situated in that portion of the Murray flood-plain between Hattah railway station and Chalka Creek. This creek issues from the river near the north-east corner of the parish of Gayfield, and runs, in a more or less westerly direction, through Gayfield, Cantala, and Brockie. About the north-western boundary of the last-mentioned parish it turns north through Cantal, Yelwell, and Kulkyne, and discharges into the Murray at the south-east corner of Colignan. Before the Murray had entrenched itself to its present depth, Chalka Creek was undoubtedly instrumental in diverting an enormous body of water from it to the remotest limits of the flood-plain. Now, however, it is a factor of little importance save in flood time, as it has cut its channel almost, if not quite, to the river's lowest level, and tends to drain the lake basins, previously referred to, almost as quickly as it fills them. Some of these lake basins, as Mournpoul and Hattah, being situated in depressions of greater depth than the majority, retain water permanently, whereas Lakes Konardin, Yelwell, Yerang, Lockie, Brockie, and Little Hattah seldom withstand the evaporation induced by a moderately severe summer, and had been dry for many months prior to our visit.

In making our first inspection of Mournpoul, we noted that, though its area had been reduced to a considerable extent by the abnormal spell of dry weather then prevailing, there were still between 500 and 600 acres covered with water, which in some parts of the lake was estimated to have a depth of twelve feet. The lake is practically encircled by sand-dunes of varying elevations, and overflows to the north-east and south-east. Its shores are flat, and sandy in the vicinity of the dense growth of Red Gum and box timber growing on and at the base of the sand-dunes, but are extremely muddy near the water's edge. The introduced tobacco flourishes in places, and, from the appearance of many upright, decayed stems of the plant far out in the water, seems to have had a more extensive range on the lake bed than at present. The only other plant noted on the shores was the Small Knotweed, *Polygonum plebejum*. This forms, in favourable situations, a dense sward, which is kept closely cropped by the cattle, sheep, and emus.

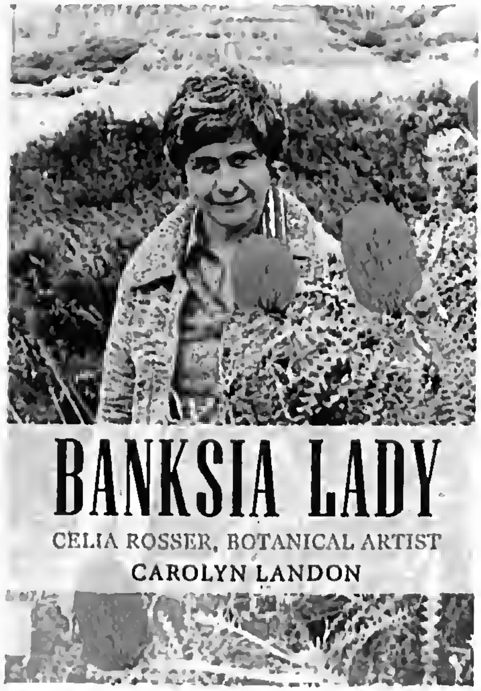
From *The Victorian Naturalist* XXXII, pp. 19–20, May 6, 1915

Banksia Lady: Celia Rosser, Botanical Artist

by Carolyn Landon

Publisher: *Monash University Publishing, Clayton, Victoria, 2015. 241 pages, paperback. ISBN 9781922235800. RRP $39.95*

Carolyn Landon has written an incredibly detailed biography of Celia Rosser, a lovely lady I had the privilege of knowing a little during my time as a PhD student at Monash University. Celia had a small studio attached to one of the research laboratories of the then Botany Department, and was painting banksia species for the first of a three-volume florilegium of *The Banksias*. At times Celia would ask any of us in the lab whether or not a colour she had mixed matched that of the specimen she was painting. Watching her paintings develop was fascinating, as was the meticulous attention she paid to ensure botanical accuracy. We are told in Chapter 13 that Professor Ross Day from Psychology would hold his breath when he watched her paint and marvelled at the delicacy of her touch, and that it took days for her to paint a single leaf. Landon tells us Ross studied perception and had come to the conclusion that attention and perception went hand in hand; indeed, that one could not exist without the other. He was impressed with the depth of Celia's perception and had noted that her focus when painting was such that it seemed she was in a trance. In part, her perception of detail paralleled her education in the science of Botany.



Throughout the book Landon shows us the development of Celia's botanical understanding and how this improved her paintings. Celia said she needed to understand the structure and arrangement of flowers; she had to see into the plant to be able to paint the plant. Discovering the Fibonacci Spiral allowed her to do this and with it she conquered perspective so that her paintings would never again look 'flat'. This revelation was a joyous one for her; however, not all her learning was so pleasant.

When she was still a novice in her botanical art, Celia wanted to meet Norman Wakefield. She had seen his book, *Ferns of Victoria and Tasmania*, which his parents, whom she had known in Orbost, had shown her. She did not know he was well-known in the botanical world, editor of *The Victorian Naturalist*, a recipient of the Australian Natural History medallion and member of the Royal Society of Victoria, or she would not have asked her husband to write to him and invite him to look at her paintings. She remembers her encounter as one of the most challenging of her life. He picked up every picture she had ready to show him and said, as he tossed them aside, 'decorative, decorative, decorative' (p. 46). She did not have sufficient botanical detail in her paintings and was told that one of her paintings—of a *Banksia serrata*—was not what a botanical painting should be and that the composition

was not worthy of the paint she had used. But, here we see the strength of Celia's character. After a bit of a cry she decided this was her first botanical lesson and she would 'show him'. If anyone has seen her paintings in *The Banksias*, they will know she certainly has.

As with any artform, one must understand the tools, in order to do the best work. For Celia, this included paper. In chapter 9 we read that she attended a seminar by Ken Hall, an art restorer, in which he dealt with the use of paper to ensure longevity of a painting. It sent Celia into a panic because he showed what would happen to an artwork if it was done on acidic paper, and told them which paper to avoid. Celia realised (horror of horrors!) that the Maud Gibson body of work she had completed for the herbarium would show damage within 20 years. She had to tell the Herbarium. But she couldn't face telling the Botany department that her painting of *Banksia serrata* for the florilegium was on paper hot-pressed onto card that was not acid free, and would show deterioration with time. Each Monday it had been Celia's habit to display the painting in the large common room of the Botany Department so people could see its development. But after the seminar she had raced to Hall and begged him to help her. She was willing to pay anything. So for three weeks the painting was treated so it would not show the expected deterioration with time and Celia had to field questions concerning its whereabouts.

The book details both Celia's private and public life. As she became more famous, Celia had to become accustomed to public speaking. She recalls that:

> Professor Eric Glasgow decided I had to say something at this launch. But I was really too scared. He pushed me up onto the landing of a stairway and I was about to cry. I was so shy, I couldn't say naught from a chook's foot. I was embarrassed that I didn't have a proper education like my audience did. My worst time was at the gardens when I had to speak in front of 200 people. I nearly died on the spot because I couldn't remember one word I intended to say. Someone else had to take over.' (p. 171)

Thankfully, two of her friends, Golda Isaac and Betty Duncan, organised meetings of small groups of faculty wives, at which Celia could practice her speeches.

Celia was a young adult at a time when it was considered that the first priority of women should be marriage and the care of the home and family. Thus, in *Banksia Lady* we read of the battles and changes in Celia's life that led to her emergence and subsequent eminence as a successful artist who retained her 'inappropriate' Australian turn of phrase at functions. At one event she was pushed into reading a paragraph from an article. As she looked it over to see what she had to read she blurted out 'Oh! Shit!' when she saw a banksia had been named after her, *Banksia rosserae*. After an instant of silence, everyone rolled around laughing.

Celia Rosser was honoured with the Medal of the Order of Australia in 19 , for her contribution to botanical art. In 1997, she received the Jill Smythies Award for Botanical Illustration. The Celia Rosser Medal for Botanical Art was established by The Friends of the Royal Botanic Gardens and is awarded every two years in celebration of Celia's outstanding work.

Banksia Lady is incredibly detailed and will give you hours of reading. By the time you have finished reading the book, you will feel you have known Celia Rosser all her life. Carolyn Landon has done an excellent job of melding Celia's memoirs with her own research, and in the process allows the reader to peer into Australian history, botanical history, academia and, of course, botanical art.

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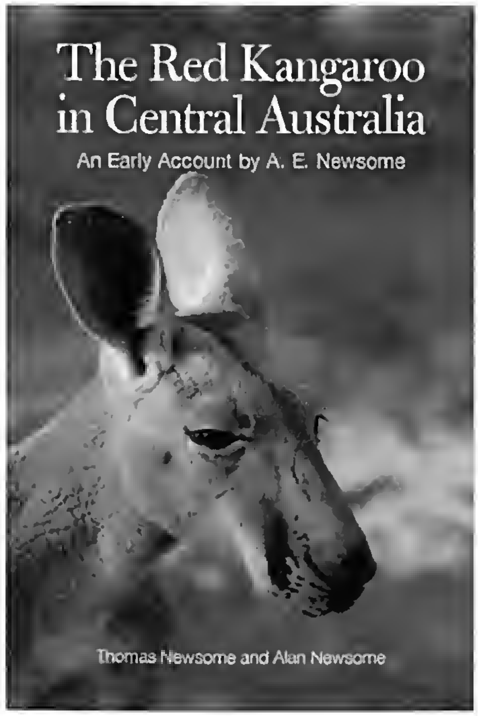
The Red Kangaroo in Central Australia: An Early Account by A. E. Newsome

by Thomas Newsome and Alan Newsome

Publisher: *CSIRO publishing. 176 pages, paperback. ISBN 9781486301553. RRP $ 39.95*

Alan Newsome was one of Australia's great naturalists and also a leading scientist whose early work focused on the biology of the Red Kangaroo *Osphranter rufus*. His work on the species began in 1957 and, unbeknown to his family, he had been preparing a book on his research which the publisher (Collins) was expecting to be completed in 1975. However, like so many things in people's busy lives, it got put aside; why it was never completed remains a mystery. In 2010 his son Thomas discovered the manuscript in a box of materials his father had left behind in his son's Canberra garage and, after a thorough read of it, Thomas decided to edit it for publication. I suspect Alan intended this book to be primarily an account of the biology of the Red Kangaroo, elucidated by his field work. If readers treat it as such, they will be somewhat disappointed as there have been many more accounts of kangaroo biology published recently that are much more up-to-date and complete. Indeed, this journal has published reviews of such books.



What makes this book a fascinating read, however, is the description of how this pioneer of ecological research went about his work. As the preface notes:

> It is rare for an ecologist to write reflectively and personally about the experience of discovery, especially during the early stages of a career ... I suspect it is also because few early career scientists have a journey that results in the kind of pioneering discoveries that Alan's did (p. xx).

Alan Newsome's research dispelled many myths and incorrect claims about Red Kangaroos. His blend of acute observational skills of a naturalist combined with rigorous scientific examination helped answer these questions:

> …why were red kangaroos so abundant on open plains and creeks during droughts, and more so on some than others? Where did they disappear to after rain? Why did they sometimes congregate to form large mobs? What did they eat and did they compete severely or at all with cattle and sheep? How did kangaroos foul pastures as claimed? How could 5 to 10 shooters work one 500 km² plain 50 km north of Alice Springs night after night in the 1950s without making an impression on numbers? Their breeding would seem to be prodigious for such to happen. So what were the reproductive processes, and what ensured reproductive success?.....Why did kangaroos appear to be more numerous on cattle country than land never stocked? Was it due to stock waters man has made? If so, why were kangaroos so rarely seen at water? Had kangaroos always been so numerous? (pp. 9–10).

For so many questions to be answered in such a slim book is remarkable, especially when they are explained so clearly and logically!

Explorers' accounts of Central Australia suggest the Red Kangaroo was quite rare before

European exploitation of the environment. Yet Newsome observed huge mobs—one of about 1500 animals south of Alice Springs. These massive changes in numbers reflect significant environmental change—change that Newsome also noted had deleterious effects on small to medium sized fauna, which was facing extirpation. His observations and suggested explanations make interesting reading.

Thomas Newsome notes his father rated his paper 'The Eco-Mythology of the Red Kangaroo in Central Australia' published in 1980 as his favourite, yet the manuscript proved very difficult to get accepted and remains infrequently cited. Fortunately it is reproduced in full in the book. I found it fascinating in demonstrating Indigenous myths that turned out to be based on sound ecological knowledge. Newsome's work was prescient—today we should recognise the value of Indigenous knowledge as a sound basis for ecological research and that proper management of our natural assets are best achieved by a blend of Indigenous wisdom with scientific work.

During Newsome's 16 field trips to the centre between 1959 and 1962 he shot 2000 Red Kangaroos! That was the way in those days—even small mammals were usually caught using break-back traps! I wonder how such research propositions would have fared in today's environment where work must be approved by independent animal ethic committees?

This is an important book which needs to be read in the context of when it was written and when the research was carried out. In his foreword, Hugh Tyndale-Biscoe believes this book rates with other natural history classics such as Ratcliffe's *Flying Fox and Drifting Sand,* Frith's *The Mallee Fowl: the bird that makes an incubator* and Rolls' *They All Ran Wild.* This may be an exaggeration (it is a slim volume) but certainly field naturalists will enjoy reading about the early journey Newsome took in his field work career.

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Understanding our natural world: The Field Naturalists Club of Victoria 1880-2015

by Gary Presland

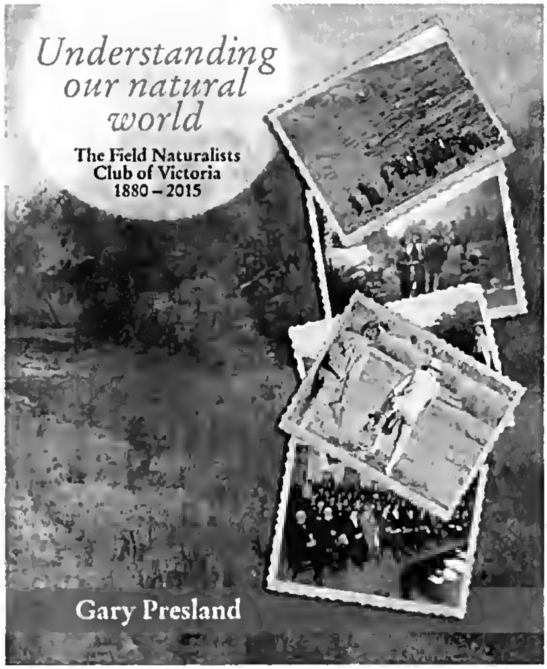
Publisher: *Field Naturalists Club of Victoria, Blackburn, Victoria 3130, 2016. 275 pages, paperback. ISBN 9780975233924. RRP $30.00*

It is hard to appreciate the full impact the Field Naturalists Club of Victoria (FNCV) has had on our landscape, culture and heritage. Just how many children have been inspired by walks and workshops to take up environmental careers? How many contributions have members made over the decades, informing the policy decisions that have shaped our suburbs, parks, farmlands and forests? How many members have discovered new species and recorded new localities across the entire taxonomic spectrum through their association with the FNCV? How much richer is our understanding of our natural world because of the supportive, knowledgeable and inclusive environment offered by organisations such as this one?

It is within the context of this broader impact that Gary Presland presents the Club's history from 1880 to 2015. Detailed accounts of meetings, elections and procedures are carefully woven into the social fabric in which the Club has operated. Presland provides the context for

the formation of the Club, with a brief history of environmental knowledge systems, leading ultimately to the rise of nineteenth century societies to promote public knowledge and education. Powered by a rising enthusiasm for nature study and outdoor activity in the early twentieth century, many such clubs and societies arose across Australia. Scientific societies catering to academic interests formed alongside naturalist societies with a broader public membership and engagement. Presland outlines the important relationships between the FNCV and formal institutions, including Museum Victoria, the Royal Botanic Gardens, and various parks and wildlife services, in terms of both personnel and facilities. The complex and changing relationship with the conservation movement is discussed along with the Club's contributions to environmental survey work and anthropological research.

One of the most striking features of the Club has been its role as a conduit for otherwise excluded groups into environmental science and policy. The Club has provided an important route for those without professional training—the citizen scientists—to make important contributions to environmental knowledge. Women who might be excluded from professional organisations could participate on an equitable footing here, sometimes with spectacular success. In 1922, for example, a 48 year-old housewife from Blackburn presented her first paper on orchids to the Club. Edith Coleman would go on to produce hundreds of articles for *The Victorian Naturalist*, academic journals, newspapers and magazines, and become an internationally respected expert in orchidology. In 1949 she became the first woman to be awarded the Australian Natural History Medallion. Such achievements epitomise the value of community organisations like the FNCV.



There are a great many charismatic and interesting characters one could focus on from the Club's long history, and a great many of them have been given short biographies in this book, written both by Presland and former president and Club stalwart, the late Sheila Houghton. This book provides an enjoyable story of a worthy organisation, its enthusiastic members and its significant contribution to Victoria's recent history. Where would our understanding of our natural world be without it?

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